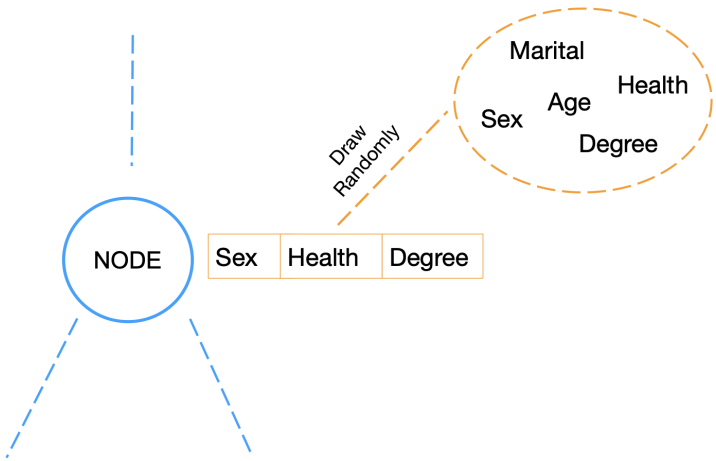
Introduction to Machine Learning

Random Forest: In a Nutshell

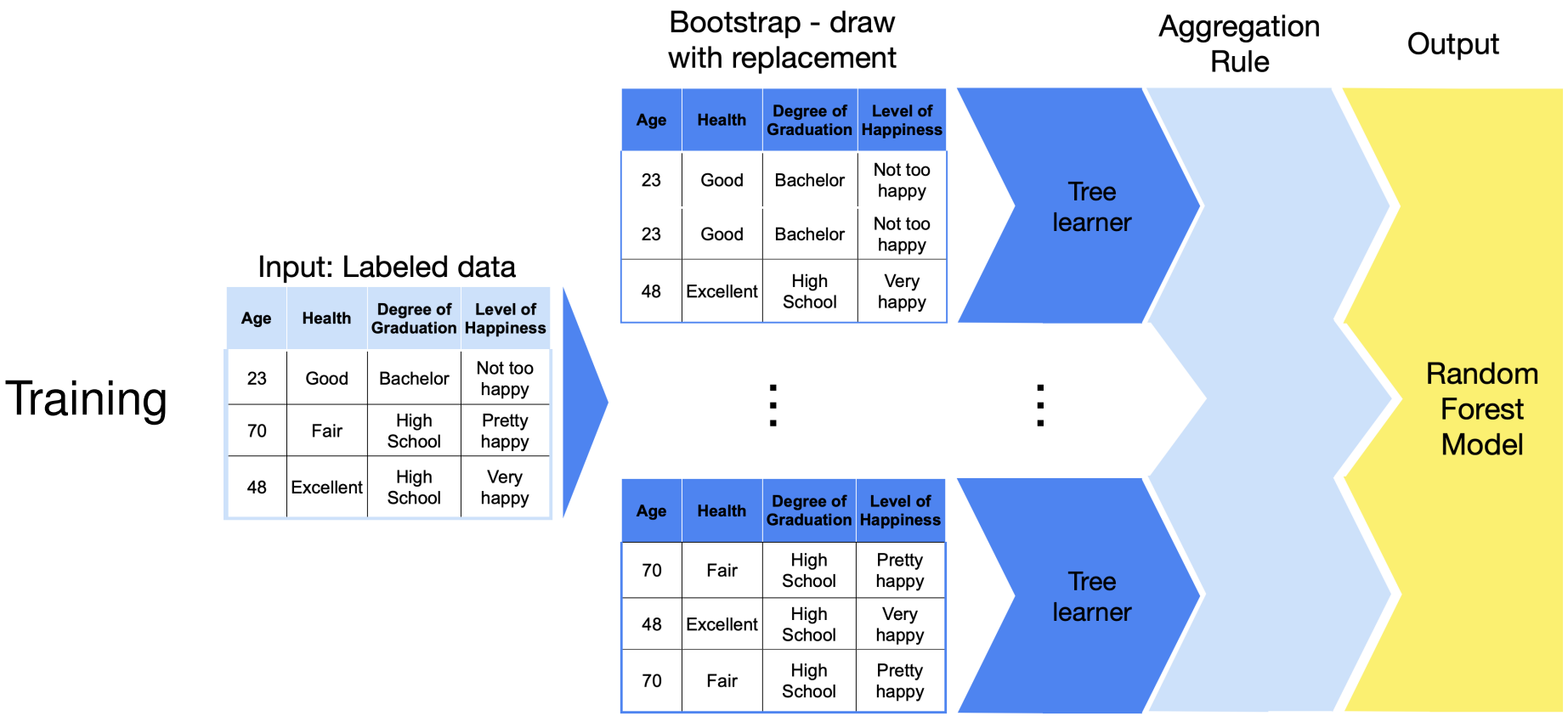


Learning goals

- Understand basic concept of random forest
- Know basic aggregation rules
- Understand concept of feature importance

LEARNING AND PREDICTION WITH RF

- Stabilizes tree learner by bagging (bootstrap aggregation)
- Randomizes tree learner and combines models into one meta model
- Can be adapted to learning task, i.e., classification or regression



Age	Health	Degree of Graduation	Level of Happiness
23	Good	Bachelor	Not too happy
70	Fair	High School	Pretty happy
48	Excellent	High School	Very happy

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LEARNING AND PREDICTION WITH RF

Prediction

Input: Unlabeled data

Age	Health	Degree of Graduation	Level of Happiness
41	Fair	Bachelor	?
35	Good	Bachelor	?
22	Fair	High School	?

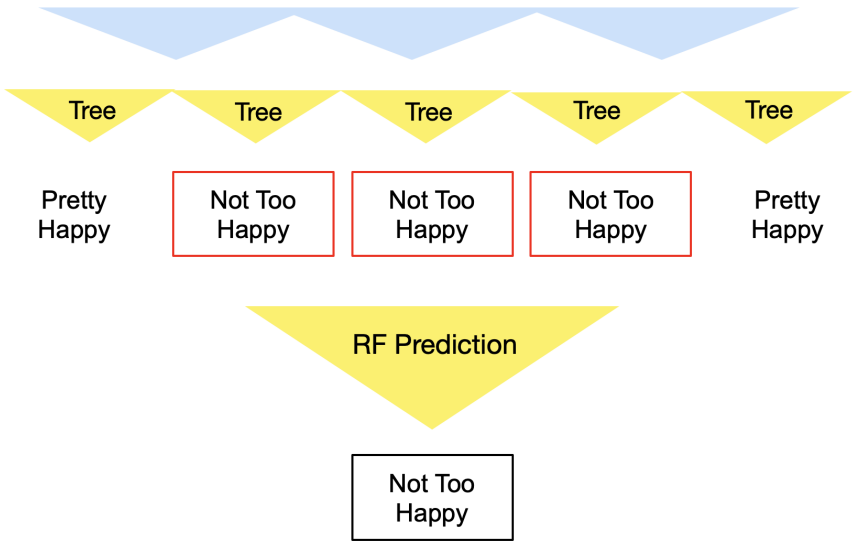
Prediction

Level of Happiness
Not too happy
Pretty happy
Not too happy

AGGREGATION RULES FOR DIFFERENT TASKS

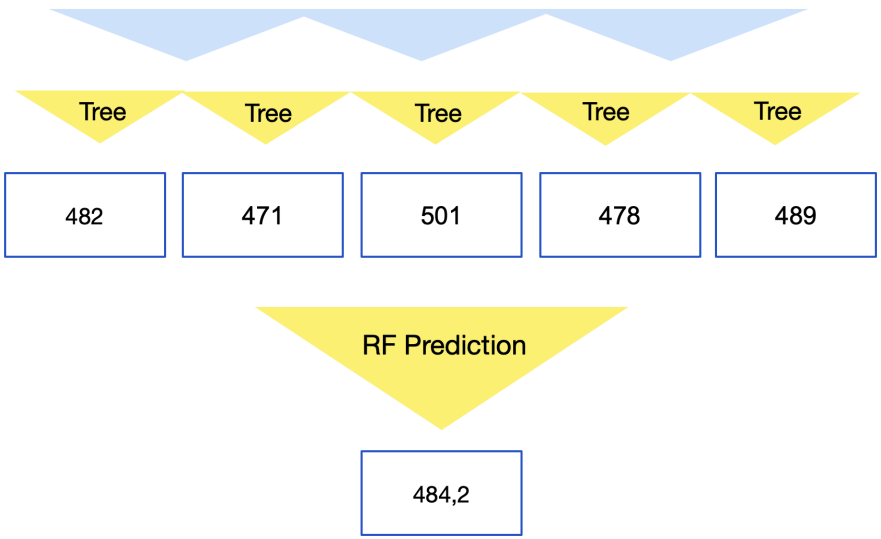
Classification Task - Majority Vote

Age	Health	Degree of Graduation	Level of Happiness
41	Fair	Bachelor	?



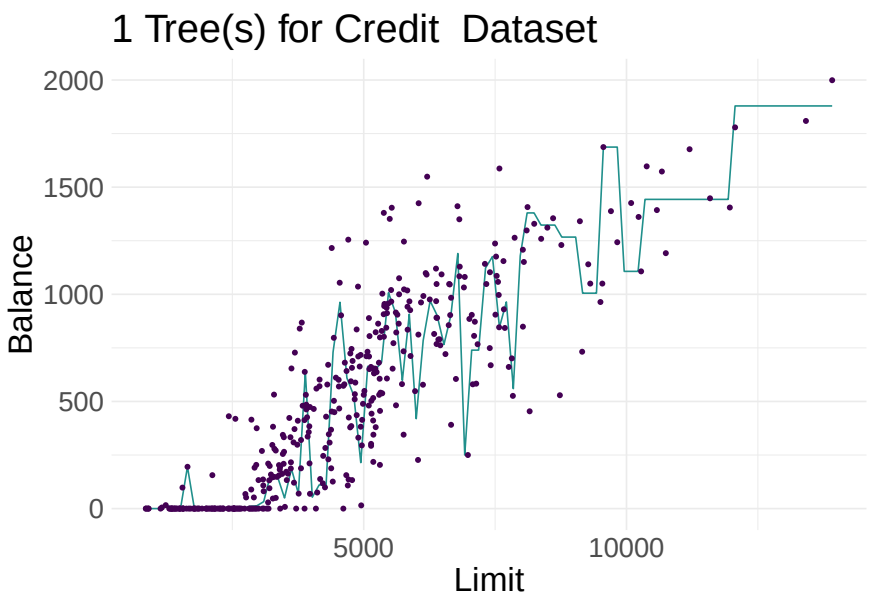
Regression Task - Averaging

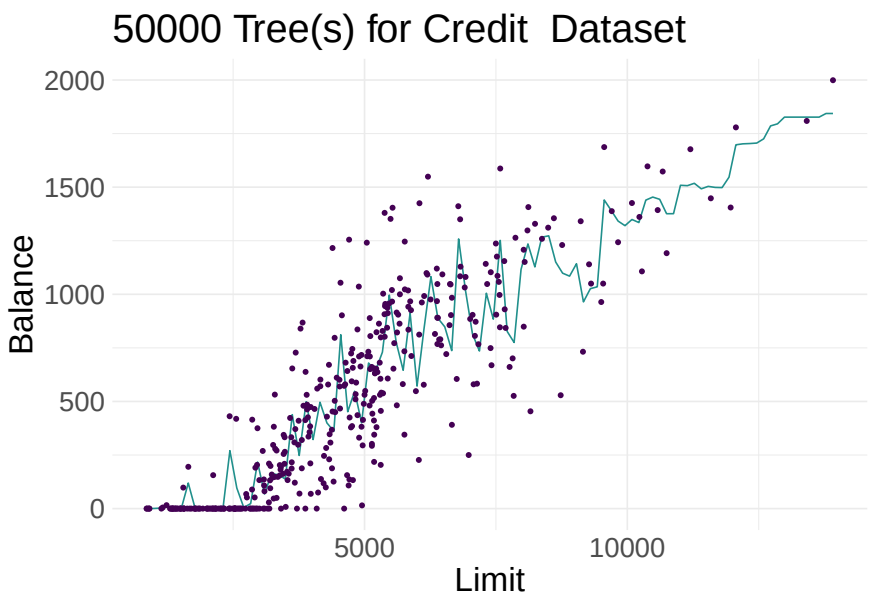
Rating	Income	Credit Limit	Credit Card Balance
107	32.318	4351	?



PERFORMANCE OF RF

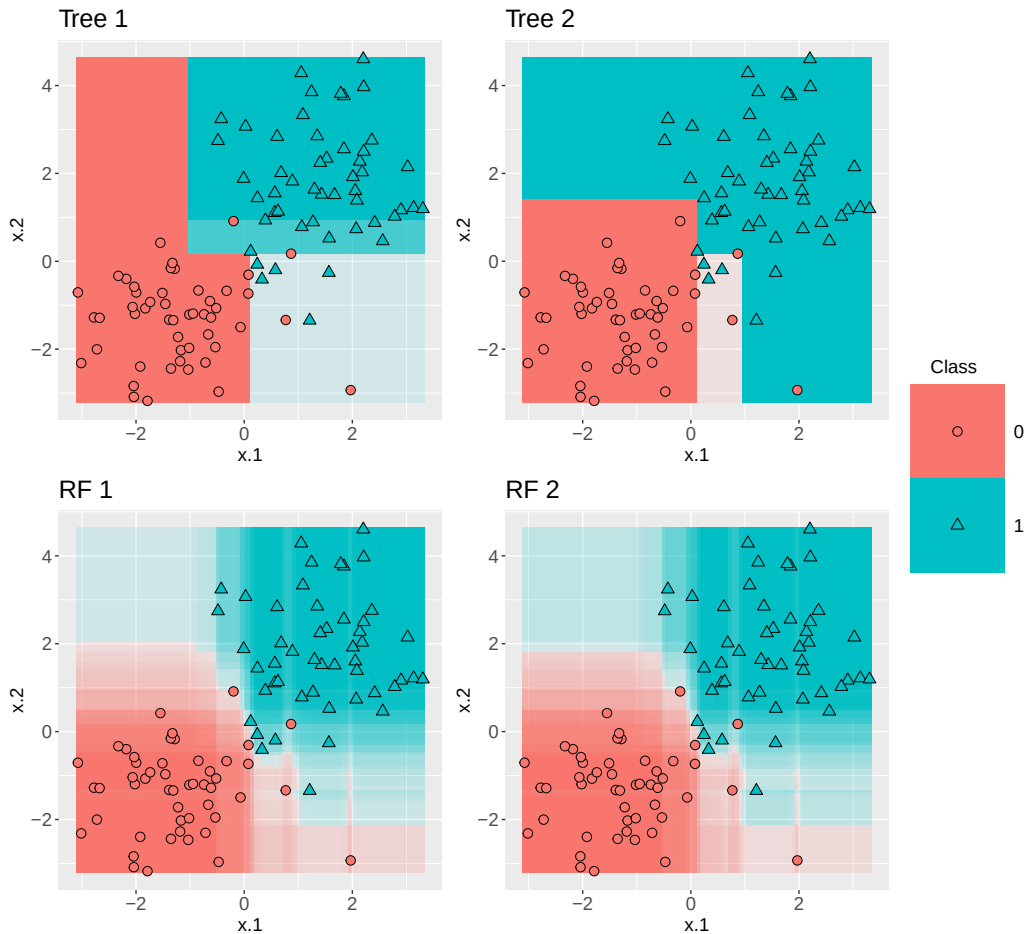
- In general: Increasing the ensemble size stabilizes the predictions
  - For regression tasks the stabilization is often not sufficient.





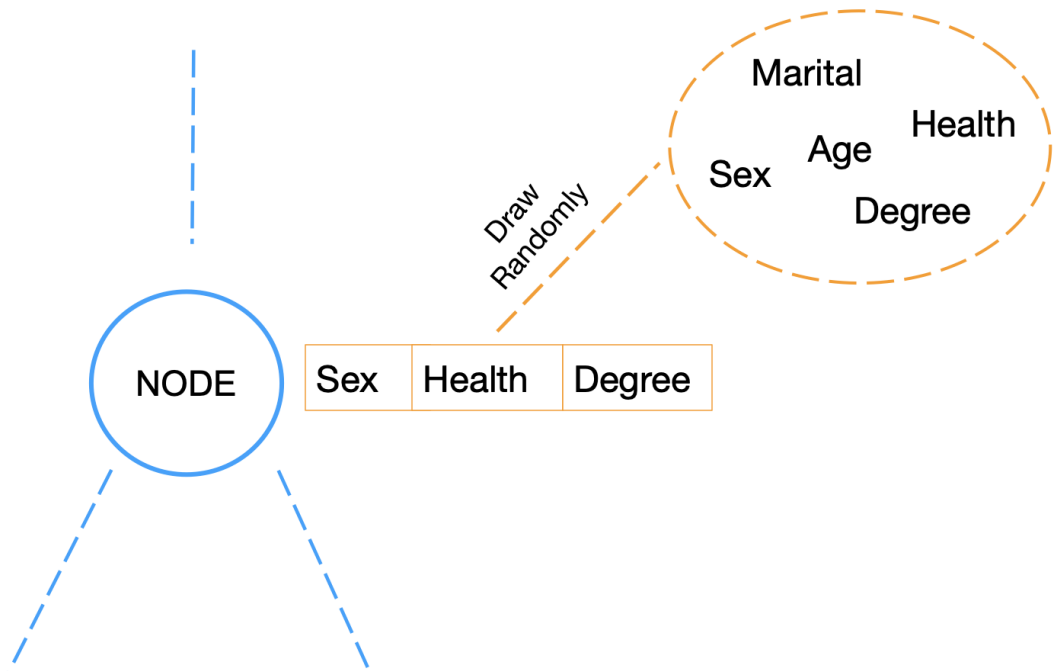
PERFORMANCE OF RF

- RF performs well for classification tasks:
  - Two different trees $\rightarrow$Two different decision regions
  - Two different RFs $\rightarrow$Same decision regions



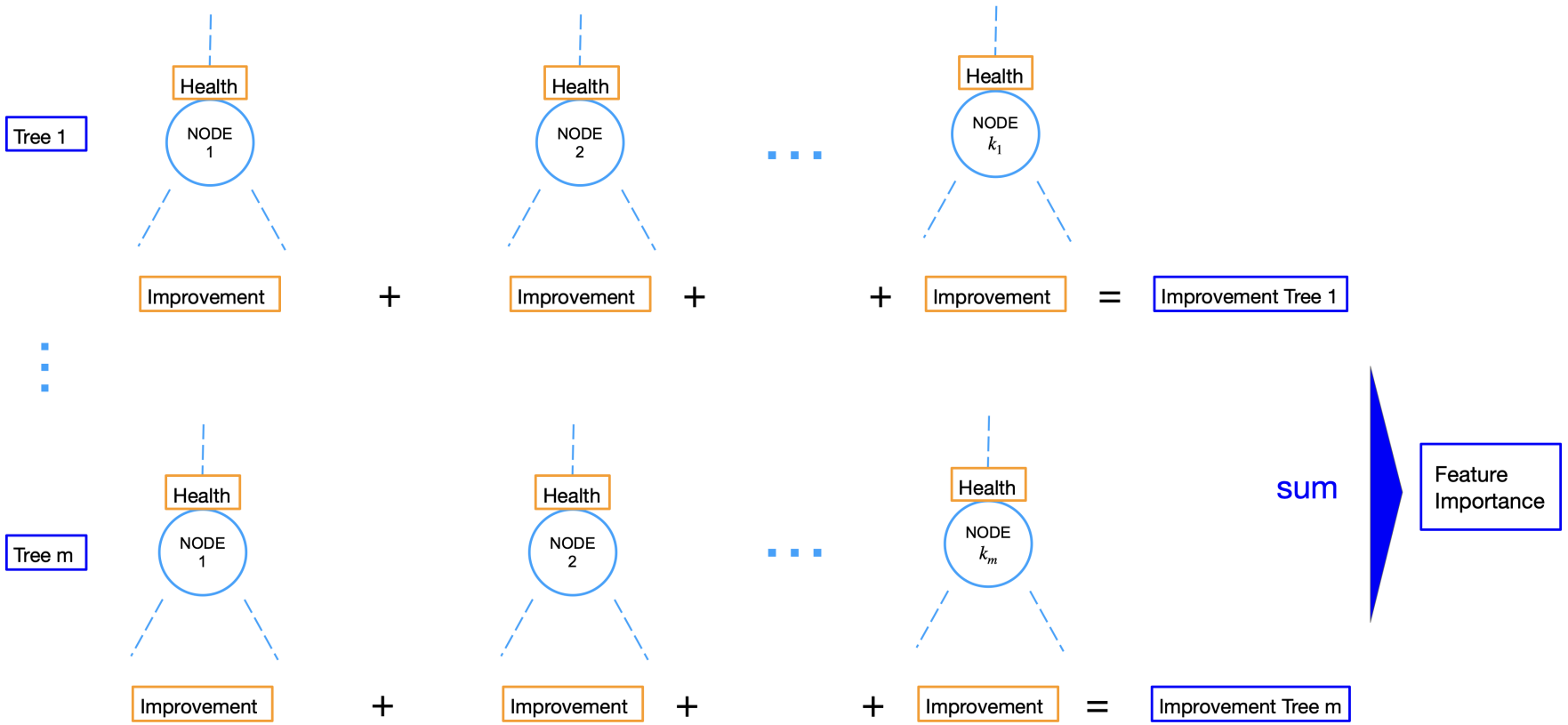
PERFORMANCE OF RF

- Trees should be decorrelated, i.e., make mistakes in different directions
- Avoid correlation by
  - Bootstrap sampling
  - Randomized splits. In each node of each tree, consider different features for splitting:



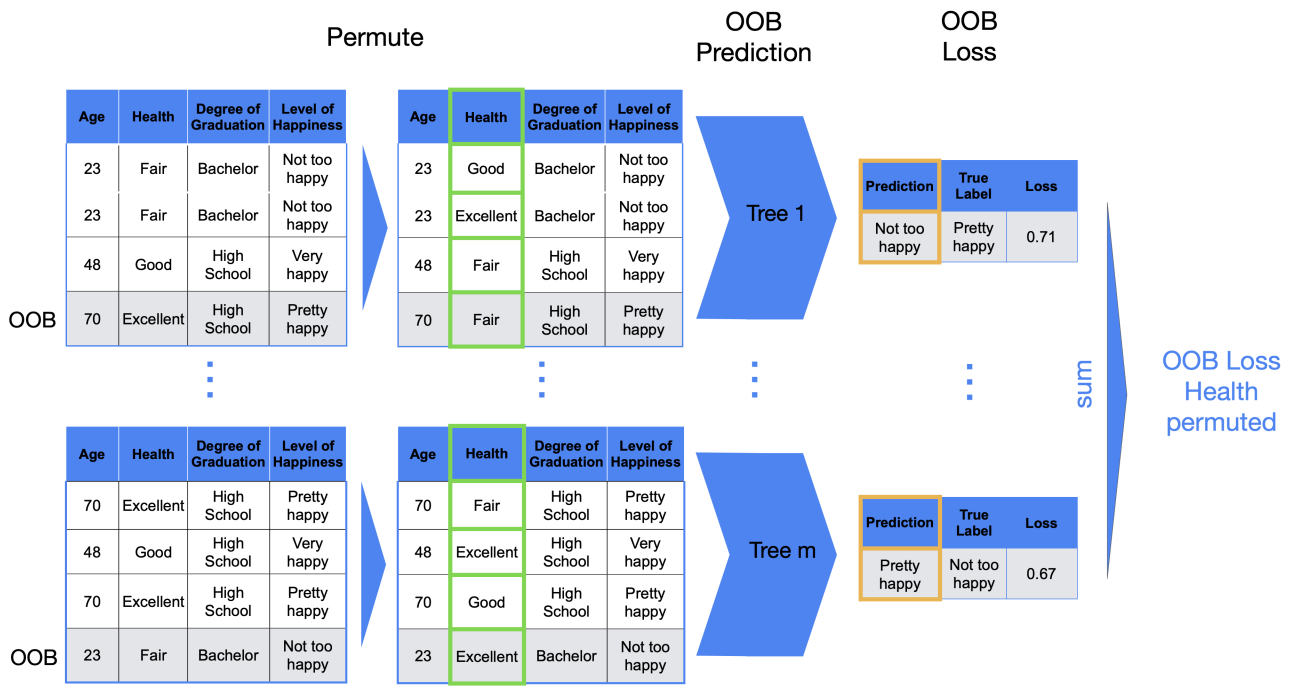
FEATURE IMPORTANCE

- Measure contributions of different features to the model:
  - Measure based on improvement in splitting criterion
  - E.g. Feature importance of 'Health', search all nodes with 'Health' as splitting variable:

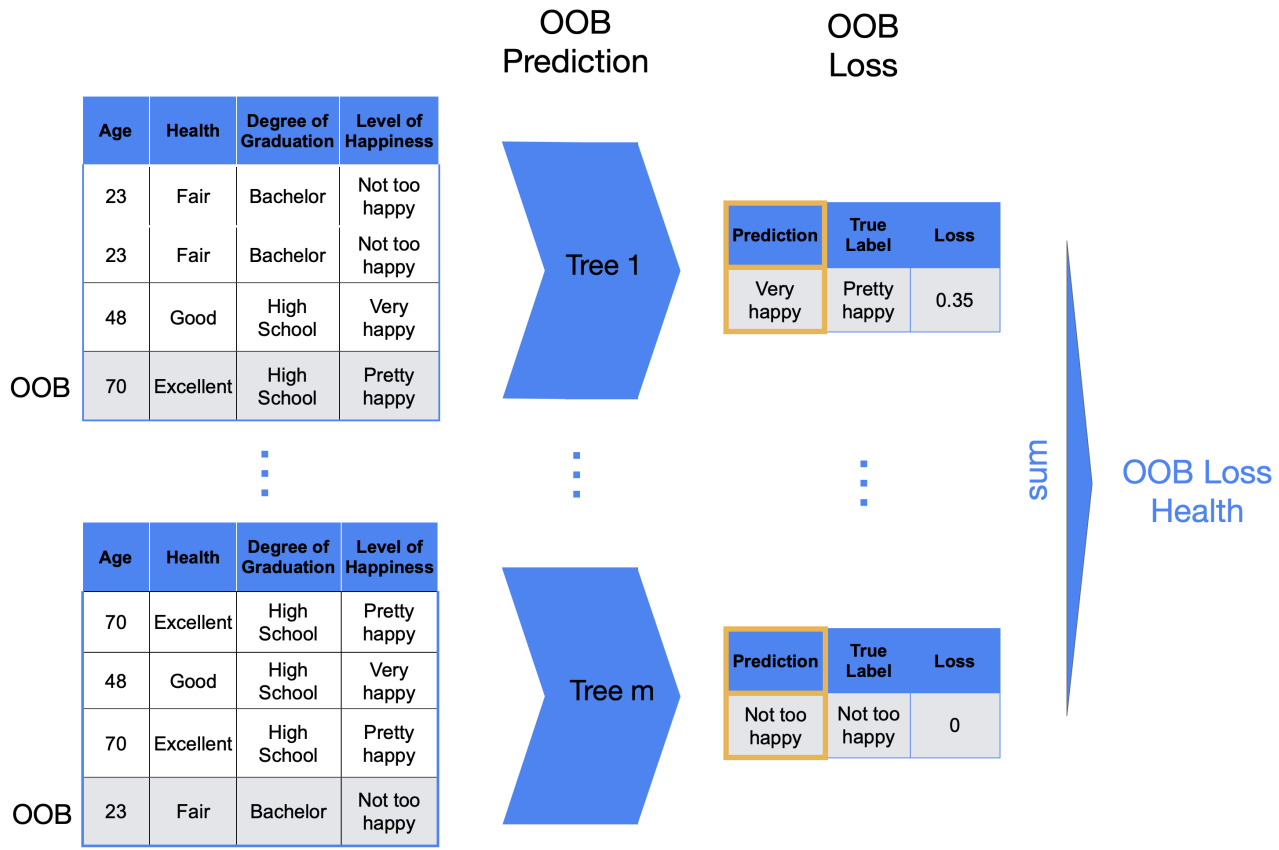


FEATURE IMPORTANCE

- Measure based on permutations of OOB obs (observations not included in bootstrap sample)
- Difference between loss of permuted-model prediction and original model prediction



FEATURE IMPORTANCE



Feature Importance = OOB Loss Health Permuted - OOB Loss Health